30/05/2018

20+20+20+16+(10)=86

T.E. | sem - VI (CBGS) | CHEM

sub - CRE - II

Q. P. Code: 21946

(Time: 3 Hours) **[Total Marks: 80]**

N.B. (i) Question number 1 is compulsory.
(ii) Answer any three questions from rest.
(iii) Assume suitable data wherever necessary.

Q. 1 a) Explain Step input experiment for RTD measurement. [5]

b) In an experiment to determine the pore volume and catalyst particle porosity the following data were obtained on a sample of activated silica (granular, 4 to 12 mesh size):

Mass of catalyst sample placed in chamber = 101.5 gm
Volume of helium displaced by sample = 45.1 gm
Volume of mercury displaced by sample = 82.7 cm^3

Calculate the pore volume, density of solid material in the catalyst & the porosity of the silica gel particles. [5]

c) Derive design equation of Plug flow reactor containing solid catalyst. [5]

d) Define the following terms [5]
(i) Effectiveness factor (ii) Mean residence time (iii) True density
(iv) Apparent density (v) Bulk density

Q. 2 a) The following data were obtained from a pulse input to a vessel. [15]

time, min	0	1	2	3	4	5	6	7	8	9	10	12	14
C, (gm/m^3)	0	1	5	8	10	8	6	4	3	2.2	1.5	0.6	0

Plot the C and E curves & determine the fraction of material leaving the vessel that has spent between 3 & 6 minutes in the vessel & the fraction of material leaving that has spent between 7.75 & 8.25 minutes in the vessel.

b) Explain tank in series model in brief. [5]

Q. 3 a) Develop a Langmuir – Hinshelwood expression for a gas – solid catalytic reaction of type [12]

$$A + B \rightleftarrows R$$

When adsorption of B is rate limiting step.

b) How much catalyst is needed in a packed bed reactor with very large recycle rate (assume mixed flow) for *63%* conversion of *2000 mol/hr* of pure gaseous A at *3.2 atm and 117 °C* if the stoichiometry and rate are given by: [8]

$$A \longrightarrow 4R, \qquad -r_A = 96.55\ l/(h.kg.cat)\ C_A$$

Q. 4 a) Oxidation of NO is catalyzed by an active carbon according to the following rate: [12]

$$-r' = \frac{P_{NO}^2 P_{O2}}{a + b\,P_{NO}^2 + c\,P_{NO2}}, \quad \frac{mol\ NO\ converted}{g.cat.h}$$

where $a = 0.0001619$, $b = 4.812$, $c = 0.001352$, p = *partial pressure in atm*

Find the volume of a reactor for converting *50 metric tonnes per day of NO to* NO_2 when using air *NO* mixture containing *15 mole % of NO*. The conversion of *NO is 90 %*. The bulk specific gravity of catalyst is *0.48* and the total pressure is *3 atm*.

b) Calculate the time required to burn to completion spherical particles of graphite (*radius 12 mm, bulk density 2.4 g/cm*^{3}) in a 12 % oxygen stream at *900 °C and 1 atm*. Assume gas film resistance to be negligible. Data: Surface reaction rate constant = $k'' = 25$ *cm/sec* [8]

Q. 5 a) An ore of uniform size particles is to be roasted in a fluidized bed reactor. The time required for complete conversion of solid particles is 20 min and the mean residence time of particles in the bed is 48 min. The solids remain unchanged in size during reaction. Calculate the fraction of the original ore remaining unconverted assuming (i) the chemical reaction step to be rate controlling (ii) the ash diffusion step to be rate controlling. [10]

b) Draw and explain Shrinking core model (SCM) [10]

Q. 6 We plan to remove 90% of an undesirable impurity (A) present in a gas stream by absorption in water containing reactive B in a packed tower. [20]

A and B reacts in the liquid as follows:

$$A\ (g \longrightarrow\ l) + B\ (l) \longrightarrow\ R\ (l), \quad -r_A = kC_AC_B$$

Determine the volume of tower needed for countercurrent operation using the following data

Data:

$F_g = 90000$ *mol/h at* $\pi = 10^5$, $P_{A\,in} = 1000$ *pa*, $P_{A\,out} = 100$ *pa*

$F_l = 900000$ *mol/h*, $C_{B\,in} = 55.56$ *mol/m*^{3}

$k_{Ag}a = 0.36$ *mol/(h.m*^{3}*.Pa)*, $k_{Al}a = 72\ h^{-1}$, $a = 100\ m^2/m^3$

$f_l = (V_l/V) = 0.08$, $D = 3.6 \times 10^{-6}\ m^2/h$

$C_U = 55556$ *mol* H_2O/m^3 *liquid, at all* C_B

$H_A = 10^5$ *(Pa.m*^{3}*)/mol and* $k = 2.6 \times 10^7\ m^3/(mol.h)$